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THE SUPPLY OF TUNGSTEN IN 1989

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ABSTRACT

The current supply and consumption of tungsten is examined with its implications for the Army's current and future needs. World production of tungsten concentrate in 1987 was reported to have been in excess of 40,000 metric tons (MT) of contained tungsten and was produced by only a few countries, mainly the People's Republic of China and the USSR. This production was shown to have been skewed due to market conditions. Therefore, the evaluation was done with 1984 as the base year, since it had a more even distribution of tungsten producing countries. There is only one user of tungsten that exceeds the consumption of the United States, that is the USSR. The USSR typically has been able to supply its own needs and imports very little tungsten. The United States, on the other hand, had to import 100% of its tungsten requirements in 1988. The improvements in cutting tool technology have led to an overall decrease in the worldwide demand for tungsten which, at present, provide an effective increase in the supply of tungsten of 2,500 MT. The conclusion is that there should be enough tungsten to supply the Army's needs now, and in the foreseeable future.

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INTRODUCTION

The Army currently fields several depleted uranium (DU) rounds for use in large-caliber guns. The firing of these rounds causes environmental clean up problems that are expensive and time consuming. The NATO countries of Western Europe are reluctant to allow the use of DU because of environmental factors. Consequentially, there exists in the Army, the impetus to replace DU with a high density tungsten alloy known as tungsten heavy alloy. This tungsten alloy must, as a minimum requirement, be capable of performing equivalently, in terms of armor penetration, as the DU. Until this time, the use of depleted uranium has occurred (a) because it worked and (b) because it was inexpensive. Depleted uranium is the by-product of nuclear fuel enrichment and significant stockpiles exist. The first question in the possible replacement of DU with a tungsten alloy is: Do sufficient quantities of tungsten exist to supply the Army's needs?

WORLD PRODUCTION

The world production of tungsten concentrate in 1987 was at the lowest level at any time in the 1980's (Figure 1).^{1,2} In 1987, 73.9% of the world concentrate production was by the People's Republic of China (PRC), North Korea, Mongolia, and the USSR (Figure 2).¹ The one major factor that caused this high fraction to be produced by these countries was the high production, at low cost, by the PRC. It can be seen in Figure 3 that the production of concentrate by PRC has risen steadily in the 1980's even when consumption has fallen.^{1,2} Because of this abundant supply, the price of tungsten was depressed to such an extent that many mines could not remain open. All of the mines in Canada, France, and the United States were completely closed in 1987.¹ Mines in several other countries were closed as well; these included Australia, Brazil, Peru, Portugal, the Republic of Korea (South Korea), and Spain. The La Parrilla mine in Spain had the additional problem of flooding.¹ To get a more realistic view of the world's capability of producing tungsten, it is better to look at the figures from 1984, a year that showed a more even distribution in the production of tungsten concentrate. Figure 4 shows that there was production that year from North America, South America, and Europe.¹ Note that Figure 4 only lists those countries that had production greater than 1000 metric tons (MT) of tungsten content. Figure 5 shows a comparison between 1987 and 1984 in terms of the number of metric tons of tungsten content produced. It is quite apparent that only one country increased its production to any significant degree and that was China (13,500 MT to 18,000 MT). The USSR was the only other country to increase its output, but by only 100 MT.

The price of the tungsten concentrate is the overwhelming factor in whether or not a mine will stay open. The average price per metric ton unit of tungsten trioxide for the years 1983 to 1987 is shown in Figure 6. When the price exceeds \$71.50 per metric ton unit it is profitable to keep the North American mines open.* It can be seen in Figure 6 that the price has been below that level in 1986 and 1987 and continued below that value in 1988.¹ Currently, the best prospect for opening the North American mines is the Orderly Marketing Agreement (OMA) signed by the United States and China in September, 1987. This agreement limits the amount of ammonium paratungstate (APT) and tungstic acid that China can export to the United States. Table 1 shows the history of shipments and the new agreed-upon limits.

*Private communication with Dr. James Mullendore, GTE Sylvania Inc., Towanda, PA.

1. Bureau of Mines Minerals Yearbook. U.S. Department of Interior, Preprint from 1987.

2. Revised Tungsten Market Forecasts. Charles River Associates Report for U.S. Army Materials and Mechanics Research Center, August 1983.

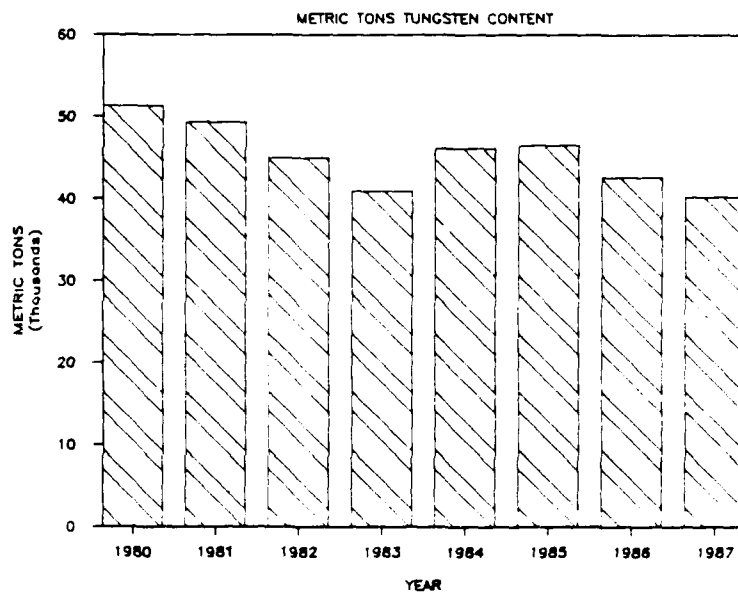


Figure 1. World concentrate production by year.

TOTAL 40,232 MT, NOTE: CANADA = 0, USA < 0.1%

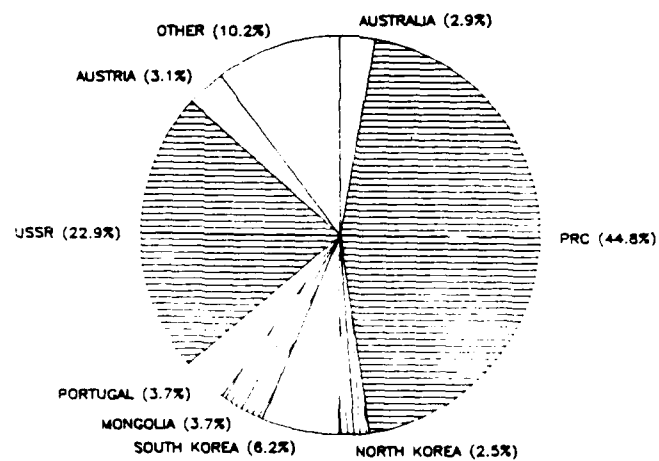


Figure 2. World concentrate production in 1987.

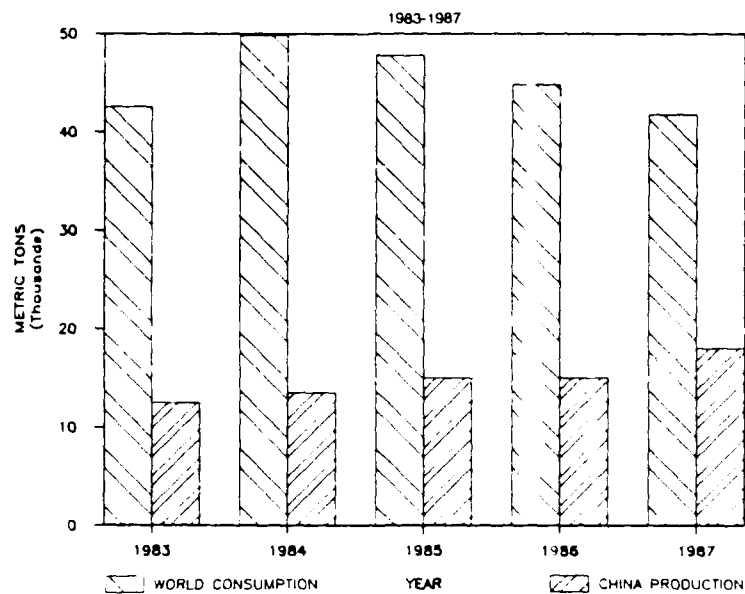


Figure 3. World consumption versus China production.

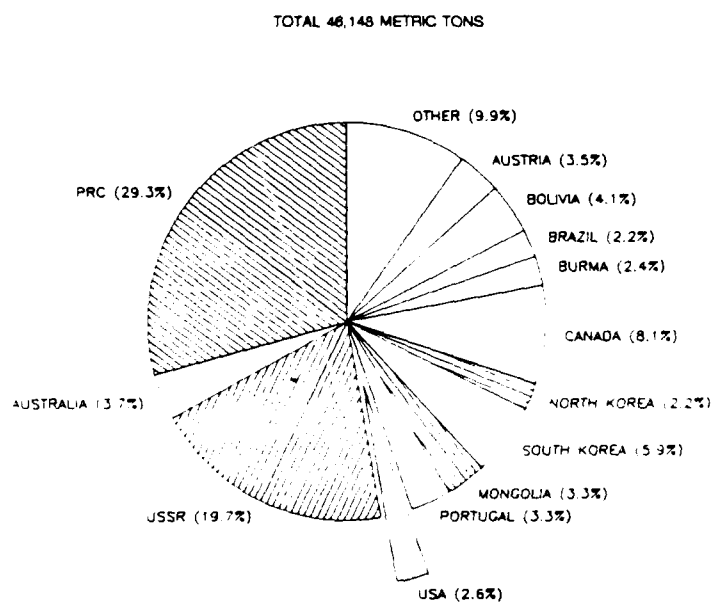


Figure 4. World concentrate production in 1984.

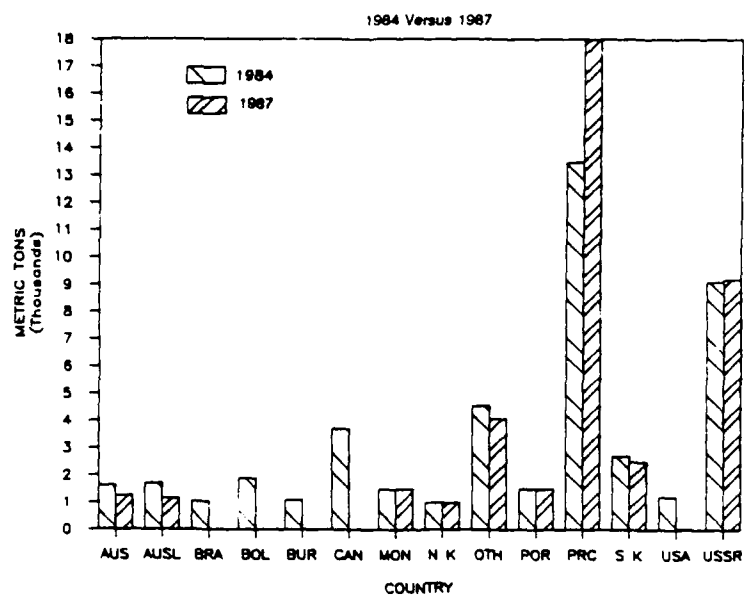


Figure 5. World concentrate production.

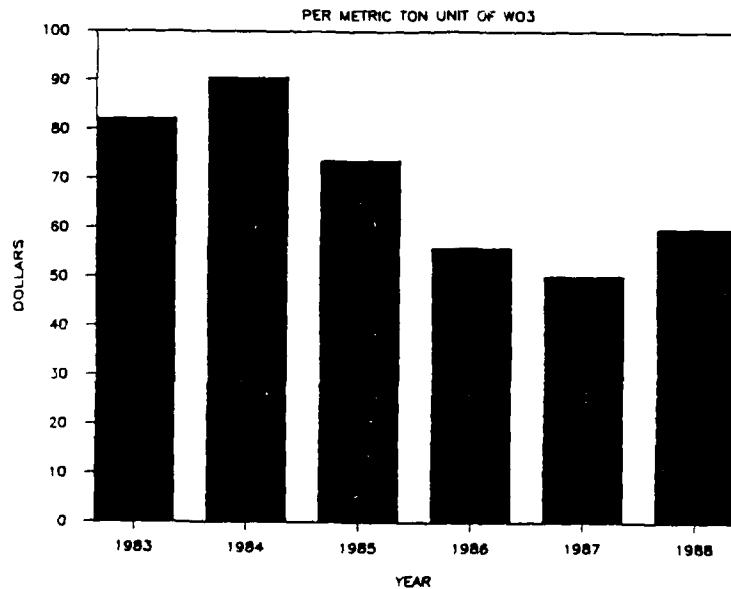


Figure 6. Average price of tungsten concentrate.

Table 1. UNITED STATES IMPORTS OF APT AND TUNGSTIC ACID FROM CHINA

Year	APT (MT)	Tungstic Acid (MT)	Total (MT)
1991	-	-	680*
1990	-	-	930
1989	-	-	880
1988	-	-	821
1987	1239	276	1515†
1986	971	156	1127

*Amount for the first 9 months of 1991

†Includes limit of 193 MT for last three months of 1987

The agreement does not take into account other forms of tungsten, in particular, concentrate, of which the United States imported 1,139 MT from China in 1987 and an estimated 4,082 MT in 1988.³ These are significant increases from 1986 in which 302 MT was imported. All forms of tungsten imported from China in 1987 accounted for 34.5% of all imports.

Since the tungsten market has been distorted by large quantities of inexpensive tungsten concentrate and other forms, one cannot get a clear picture of the producing countries' ability to supply tungsten. One possible method is to examine the production history of the various countries and determine the highest levels that were produced. Table 2 examines all of the major producing countries and lists their greatest quantity produced and the year it was produced. The total of the best years of nonsocialist countries is 33,000 MT. The largest annual quantity ever produced by these countries is 25,273 MT, in 1980. The capacity of North American mines is reported to be 12,100 MT.*

The total of the best years of the socialist countries is 29,484 MT. The production in those countries for 1987 was 29,700 MT. These countries are producing more tungsten than ever.

UNITED STATES

The United States is a significant user of tungsten in the world. Figure 7 shows the countries that consume more than 1,000 MT of tungsten per year. The only country that uses more is the USSR, using about three times as much. By far, the greatest use of tungsten in the United States is in the manufacture of tungsten carbide; 65% of all tungsten used. Tungsten metal and alloy accounts for 15%, while use of tungsten in high speed steel totals to 14% of the tungsten usage (Figure 8).^{1,3,4}

Since all of the mines in the United States have been closed for quite some time, all of the consumption of tungsten in the United States must be satisfied by imports, existing stockpiles, and recycling. Recycling should not be taken lightly since the United States has a reported recycling capacity of 2,500 MT,⁵ which is a significant contribution to a total 1988 consumption of 8,461 MT (Figure 9).³ The total recycling capacity is not being used since it

*Private communication with Dr. James Mullendore, GTE Sylvania Inc., Towanda, PA.

3. U.S. Bureau of Mines Mineral Industry Surveys, Tungsten. January 1989.

4. *International Tungsten Industry Gaining Ground*. P/M Technology Newsletter, APMI, v. 18, no. 1, January 1989.

5. Metal Powder Report. v. 40, no. 12, December 1985.

is reported that recycling is accounting for only 20% of the tungsten consumed.⁶ The recycling of tungsten carbide returns 800 MT of tungsten, 100 MT of cobalt, and 20 MT of tantalum and niobium for every 1,000 metric tons of carbide recycled.⁷

Table 2. GREATEST PRODUCTION
1970-1987

Country	Level (MT)	Year
Australia	3,590	1980
Austria	2,015	1983
Bolivia	3,188	1976
Brazil	1,358	1971
Burma	1,096	1984
Canada	3,715	1984
France	982	1986
Japan	900	1972
Peru	862	1973
Portugal	1,755	1985
South Korea	2,742	1980
Spain	565	1984
Thailand	3,350	1972
USA	4,375	1970
Other	2,509	-
Total	33,002	
Czechoslovakia	80	1982
China	18,000	1987
North Korea	2,204	1982
USSR	9,200	1987
Total	29,484	
Grand Total	62,486	

TUNGSTEN FOR ARMAMENTS

Figure 10 shows the uses of tungsten for three regions: the United States, Western Europe, and Japan.² It is quite clear that the European countries are heavy users of tungsten for armaments. Although this data is from 1980, there is no indication that the percentages have changed significantly. An estimate of the United States annual availability of tungsten for armaments in peacetime is 4,500 MT.* If the penetrator requirements were 500,000 penetrators each year, and each penetrator weighed 3.6 kilograms (8 pounds), 1,825 MT of tungsten would be needed. This is well below the estimated peacetime availability.

*Private communication with Dr. James Mullendore, GTE Sylvania Inc., Towanda, PA.

6. *Tungsten Outlook Improves*. International Journal of Powder Metallurgy, APMI, v. 25, no. 1, January 1989, p. 9.

7. BOUSSEL, P. *The Tungsten Market Situation*. Advances in Hard Metal Production, A Metal Powder Report Conference, Luzern, Switzerland, November 7 through 9, 1983.

METRIC TONS, COUNTRIES >1000 MT

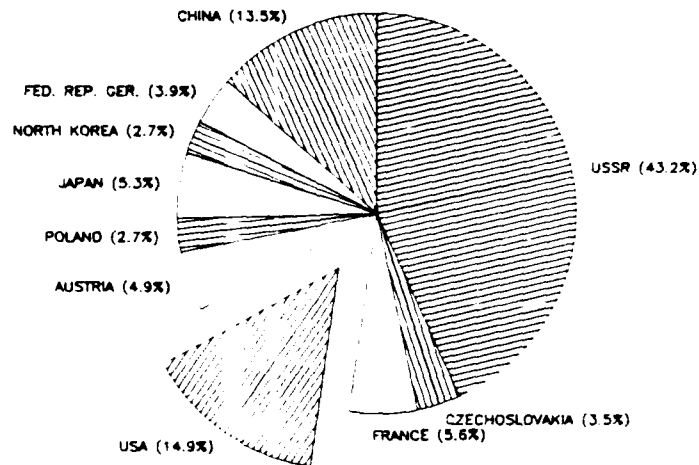


Figure 7. Concentrate consumption in 1987.

METRIC TONS TUNGSTEN CONTENT

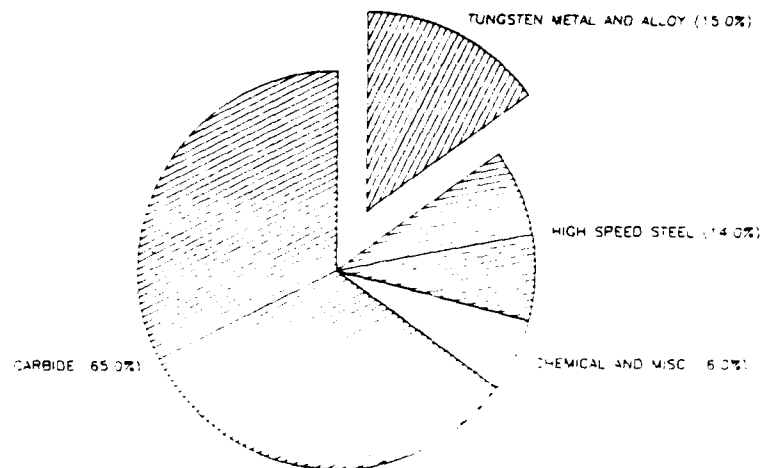


Figure 8. Users of tungsten in the United States.

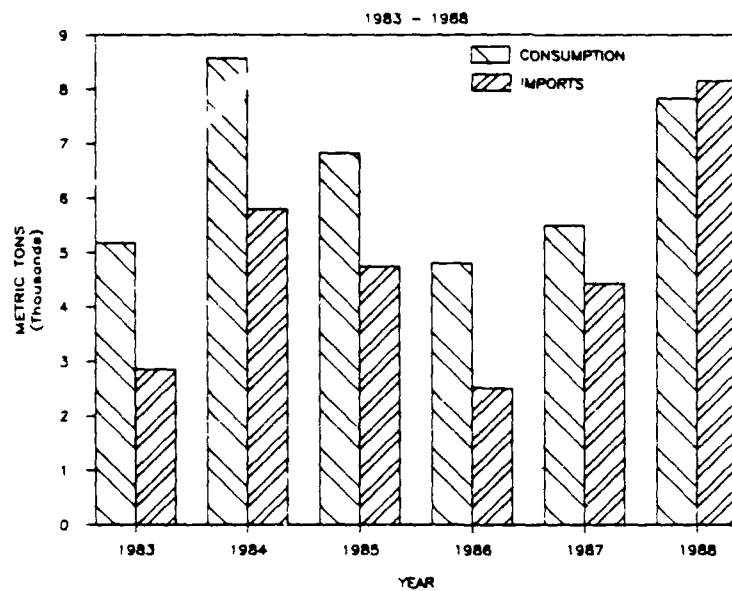


Figure 9. United States consumption versus imports.

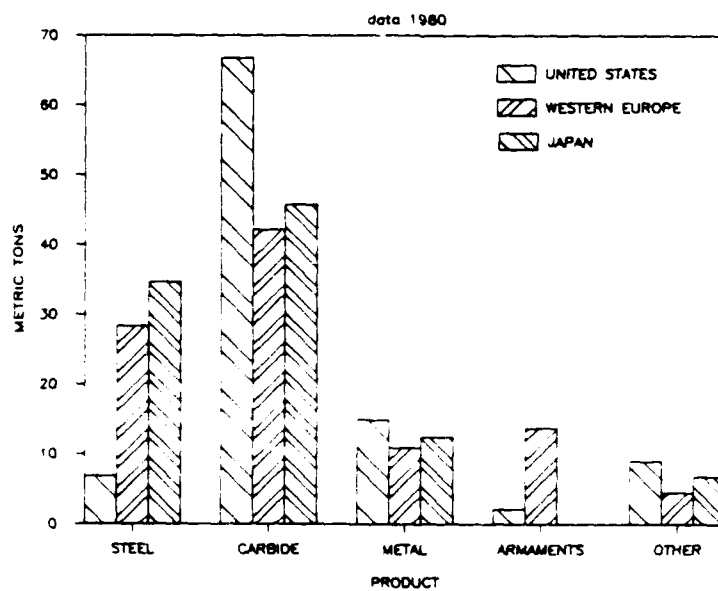


Figure 10. Consumption by end product.

OTHER FACTORS

The substitution for tungsten in several applications has led to a reduction in the worldwide demand for tungsten by 10 to 15 percent.⁶ The use of tungsten in the cutting tool market has seen a significant decrease in demand as new cutting tools and tool materials are developed. These developments include improvements in tool geometry, down sizing of tool inserts, and new fiber-reinforced ceramics tool inserts. Further, the development of polycrystalline diamond compact (PDC) tools and their use as drill blanks will further reduce the demand. Overall, it is estimated that these developments have reduced the consumption of tungsten by at least 2,500 MT worldwide.^{1,6}

CONCLUSION

The question originally asked was: Is there enough tungsten to supply the demand that would be created if the Army discontinued use of depleted uranium and switched to using tungsten heavy alloys? There are several factors that make up an affirmative answer. First, is the fact that the United States has used more tungsten prior to recent times and the tungsten mines have been able to supply the demand. Second, an increase in the demand for tungsten would likely drive the price of tungsten upward. If the price reaches more than \$71.50 per metric ton unit (price in January, 1989, was approximately \$64 per metric ton unit), then it would be profitable to reopen the North American mines, which would further supply the demand. Third, recycling could be further exploited; at this time, only about 65% of the recycling capacity is being used and increased recycling capacity is possible. Fourth, the developments in cutting tool technology have reduced the worldwide demand by 2,500 MT per year which will probably increase in the next few years but will probably not take over more than 20% of the carbide usage. All of these factors point to a favorable supply of tungsten now, and in the future.

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